

Thesis
Reports
Blum,
B.M.

ANDY GILBERT

241

UNITED STATES DEPARTMENT OF AGRICULTURE

FOREST SERVICE

March 4, 1964

FINAL
OFFICE REPORT

THE STAND DEVELOPMENT OF AN EVEN-AGED PATCH CUTTING--

A CASE HISTORY.

By

Barton M. Blum
Research Forester

Laconia Research Project
Northeastern Forest Experiment Station



Property of
National FS Library
USDA Forest Service
240 W Prospect Rd
Fort Collins CO 80526

OFFICE REPORT

THE STAND DEVELOPMENT OF AN EVEN-AGED PATCH CUTTING—

A CASE HISTORY.

By

**Barton M. Blum
Research Forester**

**Laconia Research Project
Northeastern Forest Experiment Station**

INTRODUCTION

In July of 1957 an exploratory cleaning study was established on the Bartlett Experimental Forest under the direction of Adrian M. Gilbert. The study was designed to explore the applicability of European cleaning methods to very young northern hardwood stands (on a field trial basis), and to determine the influence of these cleanings of stand composition, stocking, individual tree quality, and stand quality. The study would also provide leads to future research, and provide a proving ground for methodology.

The study was installed in Patch ⁸ 8, Compartment ⁵ 5, a densely stocked even-aged patch which was clear cut in the winter of 1950-51. The patch is approximately 0.398 acres in area on a gentle, north-facing slope. The adjacent area is old-growth northern hardwood, typical of the White Mountain region.

This study was to be part of a proposed doctoral thesis at Syracuse University, and no formal working plan was initially prepared at the request of the Syracuse faculty.

Two blocks of three 1/100-acre plots each were established in the patch in 1957. The plots and blocks were surrounded by a 10-link isolation strip. An additional block of 3 plots was established a year later, in August and September of 1958^{1/}. The first two blocks, numbered I and II, were treated in August, 1957. The third block, number III, was treated in January, 1959.

^{1/} See: Establishment report--Cleaning study in Northern Hardwoods, August 22, 1957, and Supplementary Establishment Report I, December 31, 1958, both by Adrian M. Gilbert.

INVENTORIES

Before the plots were treated, a complete tally was made of all stems in the main crown canopy. The criteria was that they be at least 6 feet above ground and that their terminal extend into the main crown canopy. All trees counted were recorded by species, form (quality), and, on blocks I and II, origin (whether seedling or sprout). Blocks I and II were inventoried and treated initially in 1957; Block III in 1959 (winter). All blocks were reinventoried in August of 1962.

As each plot was inventoried, a number of yellow and paper birch stems were chosen randomly as sample trees. The number of samples originally chosen on each plot is listed below:

<u>Plot</u>	<u>Block</u>		
	<u>I</u>	<u>II</u>	<u>III</u>
Refined treatment	30	23	16
Crude treatment	24	31	11
Control	25	33	24

Detailed data were recorded for each sample tree on blocks I and II, including the following: 1. origin, whether seedling or sprout; 2. species; 3. branch angle (A = Less than 40°, B = Greater than 40°); 4. branch length (A = Less than 3 feet, B = Greater than 3 feet); 5. crown class (Dom., Co-dom., Int.); 6. lean (nearest 10°); 7. sweep (None, Slight, Heavy); 8. crook (Abrupt, 135° or less, Moderate, 135° to 180°, None); 9. quality; 10. Coarseness ratio (F = twigs less than 1/3 stem diameter, C = twigs more than 1/3 stem diameter).

Sample trees were remeasured in August, 1963.

TREATMENTS

Two plots in each block were assigned treatments at random according to the following criteria:

Crude treatment--all the pin cherry, striped maple, aspen and beech root suckers were to be removed from the main crown canopy.

Refined treatment--A limited number of stems were removed from the main crown canopy, so that the remaining stems were not subject to greater snow damage than uncleared stands.

The order of removal was:

1. Striped maple sprout clumps
2. Yellow birch or paper birch stems that are forked, abruptly crooked or otherwise of poor form.
3. Pin cherry stems that hinder the development of better stems of yellow or paper birch.
4. Poorer stems of the birches that hinder the development of better stems of the same species.

The third plot in each block was designated as a control.

The effects of the cleaning treatments on blocks I and II were greatly confounded by extensive snow damage on the patch during the winter of 1957-58. The damage to block I was described as heavy (75-100 percent of the total number of ~~sap~~plings damaged) and on two of the plots in block II the damage was described as medium (50-74 percent of the stems damaged). There was no quantitative measure of the damage, and observations did not indicate any difference in the amount of damage by treatments.

Shortly after the damage occurred, the stand was observed to be recovering. In 1962 the only evidence of damage on the plots was some badly bent but surviving yellow birch stems, and numerous dead stems of all species.

THE PATCH BEFORE TREATMENT

Stocking--The patch was approximately $6\frac{1}{2}$ years (growing seasons) old at the time of the initial inventory on blocks I and II, and 8 years old when block III was established and inventoried. Total stocking at the time of the initial inventories is shown in table I.

Table 1. Total stocking on the plots,
number of stems per acre *.

Plot	I	Block II	III
Refined	16,800	10,300	7,900
Crude	12,400	15,500	5,000
Control	14,100	11,800	6,500
Average	14,433	12,533	6,466

* Includes only stems with terminals in the main crown canopy.

This stand may have been more susceptible to the snow damage that occurred in 1958 than other stands of the same age because of the dense initial stocking. This snow damage may in turn be the reason for the lower stocking in block III. This block was inventoried in the fall of 1958, after the snow damage had occurred.

Stand Composition--The stand composition at the time of the initial inventory is shown in table 2.

Table 2. Stand composition, initial inventory,
all plots combined. (Blocks I & II, Summer 1957,

Block III, Jan. 1959)

	<u>yellow & paper birch</u>	<u>B. & Hem</u>	<u>P. ch. & st. map. & asp.</u>
Block I	79%	13%	8%
Block II	70%	14%	16%
Block III	64%	9%	27%

As can be seen, the patch was successful from the standpoint of securing reproduction of the birches.

A tally of trees of sprout origin was made on blocks I and II during the initial inventory (table 3). By far the majority of the sprouts in both blocks were beech. The greater percentage of sprouts in block II reflect a somewhat greater percentage of beech in the block; no tally of tree origin was made on block III, but observations indicate that the percentage of sprouting is of the same magnitude.

Table 3. Percentage of total number of stems in blocks I and II of sprout origin*.

Plot	Block	
	I	II
Refined	11%	20%
Crude	12%	15%
Control	11%	17%

* Mostly root suckers.

IMMEDIATE TREATMENT EFFECTS

The treatments. The treatments removed a sizable proportion of the total number of stems, particularly the crude treatment.

Table 4. Percentage of the total number of stems removed in treatment.

<u>Plot</u>	Block		
	<u>I</u>	<u>II</u>	<u>III</u>
Refined	11%	21%	8%
Crude	20%	24%	20%
Control	---	---	---

By comparison a small proportion of the birches were removed in the treatments, consisting of 8 percent of the total number of birch trees on the refined plot in block II and 11 percent of the birches on the refined plot in block I.

Quite a high percentage of the initial stand component of beech and hemlock was removed in treatment, as indicated in table 5. One hundred percent of these should have been removed in the crude treatment; none in the refined.

Table 5. Percentage of the total initial component of beech and hemlock removed in treatment.

<u>Plot</u>	Block		
	<u>I</u>	<u>II</u>	<u>III</u>
Refined	5%	0 0	0
Crude	68%	85%	67%
Control	---	---	---

According to the prescribed treatment for the crude plots, all of the pin cherry and striped maple (weed species) also should have been removed. This was not the case in blocks II and III (table 6.).

Table 6. Percentage of total initial component of
pin cherry and striped maple removed in treatment.

<u>Plot</u>	<u>I</u>	Block <u>II</u>	<u>III</u>
Refined	25%	81%	25%
Crude	100%	68%	80%
Control	---	---	---

STAND DEVELOPMENT SINCE TREATMENT

Stocking—As mentioned before, most of the effects of the treatments on blocks I and II were nullified, as far as relating them to growth and individual tree development, by the extensive snow damage which occurred in the winter of 1958. However, differences between the two inventories reveal some interesting stand developments over the measurement period regardless of the treatments.

The nature of the inventories was such that true mortality cannot be calculated. Only those trees were counted that were at least six feet tall and had their terminals in the main crown canopy (Dominants, Co-dominants, most intermediates); those trees present in the first inventory but absent in the second may be dead, or may be alive, but in a suppressed condition. Therefore, losses over the measurement period will be called attrition for the sake of correctness. Certainly, any tree that was alive but not in a position to be counted was no longer a major factor of competition other than possible root competition.

The total number of stems counted on the plots in 1962 is shown in Table 7.

Table 7. Total number of stems per acre in 1962.

<u>Plot</u>	<u>I</u>	Block <u>II</u>	<u>III</u>
Refined	4,000	3,100	5,100
Crude	3,000	4,100	3,900
Control	4,500	4,900	5,200

Compared with the initial stocking there has been a tremendous reduction in stocking on blocks I and II--more than two-thirds of the original stocking on some of the plots. The exact percentage loss is shown in table 8. The snow damage on Block I was rated "heavy" on all of the plots--probably accounting for the greater attrition on these plots.

Table 8. Percentage of attrition on the plots since treatment.

<u>Plot</u>	<u>I</u>	Block <u>II</u>	<u>III</u>
Refined	73%	62%	30%
Crude	70%	65%	2%
Control	68%	58%	20%

It should be remembered that this loss on blocks I and II occurred over 5½ growing seasons compared to 4 growing seasons for block III--and blocks I and II include the losses due to snow damage.

In spite of the seemingly high rate of attrition for most of the plots over the measurement period, the stand today appears well-stocked. While the actual number of stems per acre shown in table 7 may not seem especially high for a 12-year-old birch stand, it must be remembered that this stem count represents only those stems with their terminals in the main crown canopy.

Stand Composition. Perhaps the greatest impact of the treatments was on stand composition. The stand composition in 1962 for all plots combined is shown in table 9.

Table 9. Stand composition, 1962 inventory, all plots combined.

	<u>yellow & paper birch</u>	<u>Bs. & Hem.</u>	<u>P. cherry & St. maple</u>
Block I	91%	7%	2%
Block II	93%	2%	5%
Block III	76%	6%	18%

Again, block III differs from Blocks I & II in that it has a lower percentage of the birches and a higher percentage of weed species on the block.

In all cases the percentage of the birches increased between inventories. This increase was accompanied by a corresponding decrease in the proportion of weed species, beech, and hemlock in the stand. In both inventories the beech and hemlock component of the stand was fairly static among the plots within any one block (see table 2); the percentage of birches on any one block appeared to vary correspondingly with the percentage of pin cherry and striped maple.

There was very little change in the percentage of yellow birch stems in the stand composition over the measurement period, and most of the percentage increase in the total birch component was in paper birch stems. This indicates that the paper birch had a slower rate of attrition and was the more aggressive of the two species. Since paper birch is the least tolerant of the birches, it probably expresses dominance earlier than yellow birch. In addition, many of the yellow birch were suppressed to the point where they were no longer counted in the inventories (some were actually alive but in a prone position in the stand). This, of course, was not the case with the intolerant paper birch. It is problematic as to whether or not paper birch is less susceptible to snow damage than yellow birch.

Table 10. Changes in the ratio of paper to yellow birch
over the measurement period, all plots combined.

		<u>paper birch</u>	<u>yellow birch</u>
Block I	1957	32%	46%
	1962	43%	48%
Block II	1957	50%	20%
	1962	80%	13%
Block III	1958	26%	38%
	1962	35%	41%

As tables 5 and 6 indicate, the treatments were effective in removing a considerable percentage of weed species (pin cherry and striped maple), beech and hemlock from the plots, particularly in the crude treatments. The percentage of the stand occupied by these species in 1962 is given in table 11.

Table 11. Percentage of the stand composition occupied
by weed species, beech and hemlock in 1962.

PLOT	I		<u>BLOCK</u> II		III	
	Be. & Hem.	Weeds	Be. & Hem.	Weeds	Be. & Hem.	Weeds
Refined	3%	2%	6%	0	12%	27%
Crude	10%	0	0	0	5%	3%
Control	9%	2%	0	12%	2%	19%

In addition to the portion of weed species, beech and hemlock removed in treatment, there was a fairly high rate of natural attrition of these species between the inventories (table 12).

Table 12.--Attrition of beech, hemlock, pin cherry
and striped maple since treatment.

<u>Block</u>	<u>Be. & Hem.</u>	<u>Weed species</u>
I	81%	89%
II	94%	73%
III	40%	34%

As with the other species in the stand, a portion of this attrition on blocks I and II can be attributed to snow damage. The high attrition for pin cherry and striped maple is somewhat surprising because these species usually compete quite well with the birches in the early stages of stand development. However, in this case the dense initial stocking of the birches was probably a factor. Most of the attrition observed in these species was probably true mortality because of their relative intolerance.

On the other hand, many of the beech and hemlock which were not counted in the 1962 inventory but were in the initial inventory are undoubtedly alive. These two species are very tolerant and will hang on in the understory of a stand indefinitely.

Quality. As part of the initial inventory and the 1962 inventory all paper and yellow birch were assigned to a quality class or grade based primarily on form and freedom from disease and damage. The four grades used originally were as follows:

- Class 1. Pronounced single terminal; short, fine branches (for species); straight shaft for species; taller and larger in d.b.h. than all surrounding trees of the same species.
2. Pronounced single terminal; short, fine branches (for species); average height and d.b.h. of neighboring trees of same species; straight shaft for species.
3. Single terminal not secure; coarse branches for species; somewhat crooked for species with chance of straightening.
4. No terminal; coarse, crooked; diseased and injured.

The fourth grade was evidently combined with the third in the initial inventory of block III. Because of this, data on quality will be presented only for blocks I and II.

In an effort to eliminate some of the subjectivity inherent in quality classification of this sort, grades 1 and 2 were combined for the purpose of this report and called the "good" grade. Thus grade 3 becomes "fair" and grade 4, "poor." Table 13 shows the percentages of good, fair, and poor birches on the plots after treatment and in 1962.

Table 13. Percentages of yellow and paper birch in 1957 and 1962 by grade (Based on the total component of birches after treatment in 1957)

			Good	Fair	Poor
Block I	Paper Birch	1957	16%	35%	49%
	Y	1962	70%	20%	10%
	Yellow Birch	1957	17%	27%	46%
		1962	33%	60%	7%
<hr/>					
Block II	Paper Birch	1957	36%	30%	34%
		1962	59%	36%	5%
	Yellow Birch	1957	22%	34%	44%
		1962	38%	56%	6%

As can be seen, the quality of the birches in the stand, particularly that of paper birch, improved greatly over the measurement period. This change in quality no doubt reflected a higher rate of attrition in the "poor" and "fair" grade, rather than an improvement in individual stems, although some of the "fair" paper birch may have moved up to the "good" grade. It is unlikely that many of the "poor" trees moved up to a higher grade. The "poor" grade in 1957 was already on the verge of not being counted in the inventory; it was a coarse, crooked, diseased and injured tree with no terminal. In the case of paper birch, such a tree is likely to die over a 5-year period; the more tolerant yellow birch, on the other hand, may hang on in the understory for a considerable time. So, in the case of both the birches, there was probably a high rate of attrition in the two lower grades that accounted for a large part of the percentage increase in "good" stems. With the paper birch this was more than likely accompanied by an improvement of a percentage of the "fair" stems in the stand (probably through an improvement in position rather than in stem form). In the case of yellow birch, the big increase in grade came in the "Fair" grade--this was probably due to an up-grading of a very few "poor" trees, a lower rate of attrition among the "fair" trees, and a lowering of the quality of some of the stems formerly classified as "good." Again, these changes probably reflect changes in position of individuals in the stand rather than a drastic change (one way or the other) in stem form.

THE SAMPLE TREES

Detailed measurements were taken at the time of the initial inventories on a total of 217 randomly-chosen yellow and paper birch sample trees. Remeasurement of these samples took place in 1963 after 6 growing seasons for blocks I and II, and 5 growing seasons for Block III. Data for the sample trees at the time of the initial inventories are based on the following number of trees:

	<u>Refined</u>	<u>Crude</u>	<u>Control</u>
Block I	30	24	25
Block II	23	31	33
Block III	16	11	24

Growth.--The average height and d.b.h. of the sample trees at the time of the initial inventories are shown in Tables 14 and 15.

Table 14.--Average d.b.h. of the sample trees at the time of the initial inventories.

	<u>Refined</u>	<u>Crude</u>	<u>Control</u>
Block I	0.54	0.43	0.49
Block II	0.60	0.55	0.62
Block III	0.78	0.61	0.90

Table 15.--Average height of the sample trees at the time of the initial inventories.

	<u>Refined</u>	<u>Crude</u>	<u>Control</u>
Block I	10.5	9.0	10.0
Block II	11.0	11.0	12.0
Block III	13.5	11.5	14.5

For a rough idea of how the individual sample trees developed over the measurement periods, the average height and d.b.h. growth is given in Table 16. These growth figures are based on the average d.b.h. and height growth of the 151 samples remaining in 1963. These averages do not include any growth that might have accrued on the 66 trees that died over the measurement period.

Table 16. Average annual height and diameter growth for the sample trees*

	<u>REFINED</u>		<u>CRUDE</u>		<u>CONTROL</u>	
	<u>D.b.h. (in.)</u>	<u>Ht.(ft.)</u>	<u>D.b.h. (in.)</u>	<u>Ht.(ft.)</u>	<u>D.b.h. (in.)</u>	<u>Ht.(ft.)</u>
Block I	.09	1.1	.07	1.2	.04	0.7
Block II	.09	1.3	.09	1.1	.07	1.1
Block III	.14	1.8	.08	1.5	.12	1.6

** Based on 6 growing seasons for blocks I and II, 5 for block III.

When the sample trees were chosen during the initial inventories, they were classified according to crown position in relation to their immediate neighbors. Three crown positions were noted: Dominant, Co-dominant, and Suppressed. To determine whether differences in subsequent d.b.h. and height growth occurred by crown position and species, the mean annual growth for the combined samples on Blocks I and II were compared (Tables 17 and 18).

Table 17.--Mean annual d.b.h. growth of samples on blocks I and II, by species and crown classification.

<u>Species</u>	<u>Dominants</u>	<u>CROWN CLASSIFICATION</u>	
		<u>Co-dominants</u>	<u>Suppressed</u>
Paper Birch	.171	.096	.076
Yellow Birch	.092	.061	.018

Table 18.--Mean annual height growth of samples on blocks I and II, by species and crown classification.

<u>Species</u>	<u>Dominants</u>	<u>CROWN CLASSIFICATION</u>	
		<u>Co-dominants</u>	<u>Suppressed</u>
Paper Birch	1.86	1.58	1.10
Yellow Birch	1.29	.94	.33

As might be expected, those trees originally classified as dominants grew the best in both height and diameter, and this pattern was consistent by crown classification. Expected differences were also found between species, paper birch growing the faster of the two. These differences were subjected to an analysis of variance and shown to be highly significant (see appendix).

Both the height and the diameter growth shown in tables 17 and 18, particularly that for the dominant trees, is good growth for these two species (particularly the paper birch) considering that it is mean growth accrued over 6 seasons. The fastest growing individual paper birch on blocks I and II grew .32" per year in d.b.h. and 2.42' in height. The fastest growing yellow birch (originally classified as a co-dominant) grew .15" in diameter annually and 2.42' in height.

Block III was not included in the analysis because of the erratic number of samples in the various classes, the shorter measurement period, and the lack of snow damage that made only blocks I and II comparable. The mean growth and number of samples for block III is shown in Table 19. Mean height growth for this block is shown in Table 20.

Table 19.--Mean annual d.b.h. growth and number of sample trees on block III, by species and crown classification.

<u>Species</u>	<u>Item</u>	<u>CROWN CLASSIFICATION</u>		
		<u>Dominant</u>	<u>Co-dominant</u>	<u>Suppressed</u>
Paper birch	n	5	11	4
	Mean	.228	.160	.075
Yellow birch	n	No sample	5	23
	Mean		.164	.066

Table 20.--Mean annual height growth of sample trees on block III, By species and crown class.

<u>Species</u>	<u>CROWN CLASSIFICATION</u>		
	<u>Dominant</u>	<u>Co-Dominant</u>	<u>Suppressed</u>
Paper birch	2.14	2.19	1.30
Yellow birch	No sample	2.32	1.16

Mean growth for block III follows the same general pattern as in blocks I and II with the exception that the co-dominant yellow birch show somewhat greater growth than the paper birch. The erratic number of samples in each class make these averages suspect. However, block III does have generally better overall growth than blocks I and II, which could reflect a slightly better site, the lack of snow damage during the measurement period, fewer years growth on which to base the average figures, or all of these factors combined.

Changes in crown position.-- It is interesting to note that while the growth on blocks I and II followed a significant trend according to original crown classification, there was considerable change in crown classification over the 6-year measurement period. Of the 86 originally co-dominant and suppressed samples remaining in 1963, only 9 percent had moved up to a higher crown class over the measurement period. Of the 46 remaining dominants and co-dominants, however, 65 percent moved to a lower classification over the measurement period. Fifty-four percent of these moved down one crown class; 11 percent moved down two crown classes. A detailed breakdown is shown in Tables 21a, b, and c.

Table 21.--Percent change in the original crown classification of those sample trees remaining in 1963. (Blocks I and II combined)

(21a)		Dominants	
Species	% remaining dominant	% moving to co-dominant	% moving to suppressed
Paper birch	42	33	25
Yellow birch	--	50	50

(21b)		Co-dominants	
Species	% moving up to dominant	% remaining co-dominant	% moving down to suppressed
Paper birch	5	45	50
Yellow birch	--	33	67

(21c)		Suppressed	
Species	% moving up to dominant	% moving up to co-dominant	% remaining suppressed
Paper birch	10	14	76
Yellow birch	--	--	100

The aggressiveness of the intolerant paper birch as compared to the more tolerant yellow birch is quite apparent. All of the trees that moved up were paper birch, and a greater percentage of yellow birch individuals moved down than did paper birch. None of the yellow birch that were originally dominant remained so.

There is good reason to believe that the extent of these downward changes is not typical of young birch stands under normal conditions. Since the birches are both relatively shade intolerant, more downward movement would be expected than movement from a co-dominant and suppressed classes upward, but in this case the extent of such movement appears to be greater than normal. The chief reason is probably snow damage again. More than likely a great many of the samples on blocks I and II were "knocked back" slightly by the snow damage, and many may never have regained their original stature.

This is substantiated to some extent by the sample trees on block III. These trees were classified after the snow damage had occurred. Eighty percent of the samples on block III retained their original crown position; 10 percent moved up one notch, and 10 percent moved down one notch.

Mortality.--As might be expected, mortality among the sample trees varied by species and crown position also. Suppressed paper birch suffered the most mortality, followed closely by suppressed yellow birch (see Table 22).

Table 22.--Mortality of the sample trees by initial crown classification and species (% of the original number of sample trees)

Block	Species	Crown Classification		
		Dominant	Co-dominant	Suppressed
		-----Percent-----		
I and II	Paper birch	8	33	49
	Yellow birch	33	32	39
III	Paper Birch	0	8	20
	Yellow Birch	no sample	0	4

The high mortality shown for dominant yellow birch in blocks I and II is misleading; there were only 6 samples originally, two of which died.

The percentage of mortality among all of the sample trees in each plot and block is shown in Table 23.

Table 23.--Total mortality among the sample trees over the measurement period, percent of original number of stems.

	Refined	:	Crude	:	Control
	Percent	:	Percent	:	Percent
Block I	40		33		40
Block II	48		30		33
Block III	13		9		0

Natural pruning.--When blocks I and II of this study were installed, the number of branches on each one-third segment of the sample trees was recorded. In addition, those branches on the middle and top third of each stem were recorded according to their coarseness ratio (fine = twigs less than 1/3 of the stem diameter; coarse = twigs more than 1/3 the stem diameter) and their branch angle (A = less than 40°; B = 40° or more). Data was also collected on branch length.

When block III was established at a later date, the procedure was changed, and branches were not classified by coarseness or angle. Instead, total number of branches were tallied and the length of individual branches was measured. These individual branches were located by counting back from terminal buds and bud scars.

Exactly how to handle this branch data so that meaningful conclusions can be drawn from it is difficult to say. In 1963 the trees were so tall that total branch counts were next to impossible; number of branches were counted only on the lower two-thirds of the trees. In addition, the individual branches on plot III could not be located, again because of the height of the trees and the obliteration of the older bud scars.

The determination of changes in the number of branches on a particular length of bole over the measurement period was not possible because a definite length of bole could not be identified over the measurement period. And as explained before, individual branches could not be located with accuracy to determine the natural pruning capacity of branches with certain characteristics of coarseness or angle.

An attempt was made to classify each tree by the characteristics of the majority of the branches recorded in the top two-thirds of the tree at the time of the initial inventory. In this way we thought we could determine differences in the number of branches per foot (based on branch counts on the lower two-thirds of the tree, as counted in 1963) between finely branched trees and coarsely branched trees; trees with a majority of steep-angled branches and those with a majority of shallow-angled branches. Some idea of any initial differences in number of branches between these same trees could have been determined from total initial branch counts and statistically tested for significance.

Unfortunately, the majority of the branches on the majority of the sample trees turned out to be coarse and shallow-angled as originally classified. In fact, only 9 trees classified in this manner were finely branched--and only 4 trees had a majority of branches with angles steeper than 40° (out of 102 samples). Unable to locate individual branches, it was decided to abandon any attempt to determine, even roughly, the natural pruning capacity of the sample trees according to their branching habit.

SUMMARY AND RECOMMENDATIONS

Other than some fairly recent work that has been done involving height and d.b.h. differentiation in pure, even-aged northern hardwoods stands, we know very little about natural stand or individual tree development in even-aged northern hardwoods. By the same token, we know very little about the effect of cultural treatments such as thinnings or cleanings in such stands. This study was to be the beginning of work that would have helped fill this gap in our knowledge.

Primarily, this study was designed to test the applicability of European cleaning methods to young northern hardwood stands, and at the same time, provide experience for Bartlett personnel. In addition, it was to supply some information--an intangible part of the study--on the effects of the cleanings on stand dynamics. Presumably, the study was intended to yield some information on the natural development of such stands also.

While there was no formal working plan, as previously mentioned, an establishment report and a prospectus for cleanings in northern hardwood stands provided background information. In addition, an earlier working plan for an exploratory study along similar lines was available for reference.

Obviously, the importance of the study grew somewhat out of proportion, primarily because of its usefulness as a demonstration. The lack of a definitive working plan is probably another reason for the loss of the original concept of the study. And while the value of working plans is now generally recognized, this study supplied "proof of the pudding" from a personal standpoint.

As for specific recommendations pertaining to study methods, one stands out above all others: in studying changes in quality as related to stand conditions, it is essential that quality characteristics be quantified precisely. Changes in bole form, such as weep or crook, should be described or measured as precisely as possible. Where a quantitative measurement is impossible or impractical, the use of photographs or diagrams (such as used in Dave Marquis' thinning study in 25-year-old paper birch at Bartlett) is desirable.

In studying natural pruning as related to branch characteristics, stand condition, etc., it is imperative that either the location of individual branches be pin-pointed accurately, or that a definite length of bole be defined to determine changes in number of branches. Branch characteristics such as angle, length, and coarseness should be measured exactly (the best approach) or assigned to meaningful classes or groups.

The method of inventory used in this study was found to be lacking because of the subjectivity involved. Just exactly what was meant by the "main crown canopy" and where it began was sometimes in doubt. If total stem counts were deemed impractical, it would have helped to have "main crown canopy" defined specifically. Just how to determine where the "terminal" of some of these hardwood trees was located was also difficult at times.

Personally, it seems more efficient to keep a study small and eliminate as many variables as possible. Studies of changes in quality characteristics might well be individual tree studies kept separate from the larger plot studies of cultural treatments.

In spite of the question mark that may hover over many of the conclusions that can be drawn from the data collected in this study because of the snow damage, there is one redeeming feature: it is about all we have of a quantitative nature on the development of young even-aged stands. It is valuable from the standpoint of indicating trends in the development of young stands and in the growth and development of individual trees. It also points up the need for additional research in various areas of investigation.

The primary need in this respect is of course thinning and cleaning studies in even-aged hardwood stands. These studies should cover a variety of ages. Since the primary objective of most thinning treatments is improving or maintaining growth, they are usually based on the hypothesis that competition for light (or in the case of root competition, moisture) is the major limiting factor to improved growth. Is this really true? What part does past stand history play in influencing the response of birch stands to thinning? What parts do site (nutrition, moisture) genetics, and tree vigor play? Tree growth is affected by many variables, any of which might possibly limit growth singly or in combination with one another. Thinning studies should at least recognize these variables and separate their effects where possible.

We also need to know more about the development of these stands under natural conditions. In this study, the total reduction in stocking amounted to about two-thirds of the total number of stems at the beginning of the measurement period. Yet the stand at the end of the measurement period appeared well-stocked and not atypical of a stand its age. If snow damage had not occurred, would natural mortality be of the same magnitude? Young birch stands seldom appear to become stagnant, at least as we think of stagnation in softwoods. How much this competition, under natural conditions, influences the future growth (and rate of response to thinning) is one of the unknowns that bears investigating.

The data collected in this study reaffirms the Bartlett policy of choosing only well-formed, dominant or co-dominant crop trees in the extensive thinnings done in connection with compartment management. High quality, dominant trees grew the fastest and were the trees most likely to survive.

It is unfortunate that no valid conclusions can be drawn nor specific recommendations for future studies be made that pertain to the treatments this study was designed to explore. And while the stand data collected in the course of the study could be of interest to both silviculturists and ecologists, it is too inconclusive to recommend publishing, at least on a major scale. A research note might be in order, however, stressing the more interesting case history aspects of the study.

It is recommended that this study be closed out, since the fulfillment of the original objective is no longer possible, and any additional data collected would still carry the stigma of the snow damage. Work of a more formal nature dealing with the development of even-aged stands and the trees within such stands should be accelerated, as well as the evaluation of various cultural treatments applied to them.

APPENDIX

Blocks I and II

Analysis of Variance--D.b.h. growth

Mean d.b.h. growth and number of samples by species and crown classification.

Species	Item	Dominants	Co-dominants	Suppressed
Paper birch		12	18	29
		2.05	1.73	2.22
		.171	.096	.076

Yellow birch		4	12	27
		.37	.73	.49
		.092	.061	.018

Computation

Species	Dominants	Co-dominants	Suppressed	Total
Paper birch	.171	.096	.076	.343
Yellow birch	.092	.061	.018	.171
Total	.263	.157	.094	.514

$$C = (.514)^2/6 = .264196/6 = .044032$$

$$\text{Species} = .146890/3 = .048963 - .044032 = .044931$$

$$\text{Crown class} = .102654/2 = .051327 - .044032 = .7295$$

$$\text{Total} = 1.113300 - .044032 = 1.069268$$

$$\text{Sums of squares of deviation from sub-class means} = 1.069268 -$$

$$\left(\frac{2.05^2}{12} + \frac{1.78^2}{18} + \frac{2.23^2}{29} + \frac{37^2}{4} + \frac{73^2}{12} + \frac{49^2}{27} \right)$$

$$= 1.069268 - .773949 = .295319$$

$$\text{Degrees of freedom for variation within sub-classes} = 102 - 6 = 96$$

mean square for variation within sub-classes is

$$.295319/96 = .003076$$

$$\text{Mean square for error} = \frac{1}{6} \left(\frac{1}{12} + \frac{1}{4} + \frac{1}{18} + \frac{1}{12} + \frac{1}{29} + \frac{1}{27} \right) (.003076)$$

$$= \frac{1}{6} (.54373) (.003076) = (.04058) (.003076)$$

$$= .000279$$

Method of calculating error term with unequal sub-class frequencies taken from:

Walker, Helen M. and Joseph Lev. 1953.

Statistical Inference

Henry Holt and Company, New York

Variance Table

Source	Sum of squares	Degress of freedom	Mean Square	F	F _{.05}	F _{.01}
Species	.004931	1	.004931	17.6738**	3.94	6.90
Crown class	.007295	2	.003647	13.0716**	3.09	4.82
Total	1.069268	101				
Error		96	.000279			

The differences between the d.b.h. growth means for both species and crown classification are highly significant.

Blocks I and II

Analysis of Variance--Height growth

Species	Item	Dominant	Co-dominant	Suppressed
Paper birch		12	18	29
		22.34	28.38	31.93
		1.862	1.577	1.101

Yellow birch		4	12	27
		5.18	11.33	8.99
		1.295	.944	.333

Computation

Species	Dominants	Co-dominants	Suppressed	Total
Paper birch	1.862	1.577	1.101	4.540
Yellow birch	1.295	.944	.333	2.572
Total	3.157	2.521	1.434	7.112

$$C = (7.112)^2/6 = 50.580/6 = 8.4300$$

$$\text{Species} = 27.2268/3 = 9.0756 - 8.4300 = .6456$$

$$\text{Crown class} = 18.3784/2 = 9.1892 - 8.4300 = .7592$$

$$\text{Total} = 185.8645 - 8.4300 = 177.4345$$

Sum, of squares of deviations from sub-class means =

$$177.4345 - \left(\frac{(22.34)^2}{12} + \frac{(28.38)^2}{18} + \frac{(31.93)^2}{29} + \frac{(5.18)^2}{4} + \frac{(11.33)^2}{12} + \frac{(8.99)^2}{27} \right) =$$

$$177.4345 - (41.5896 + 44.7458 + 35.1780 + 6.7081 + 10.6974 + 2.9933) =$$

$$177.4345 - 141.9122 = 35.5223$$

Degress of freedom for variation within sub-classes: $102 - 6 = 96$

Mean square for variation within sub-classes is

$$35.5223/96 = .3700$$

$$\text{Mean square for error} = \frac{1}{6} \left(\frac{1}{12} + \frac{1}{4} + \frac{1}{18} + \frac{1}{12} + \frac{1}{29} + \frac{1}{27} \right) (.3700) =$$

$$(.09058) (.3700) = .03351$$

Variance Table

Source	Sums of squares	Degrees of freedom	Mean square	F	F .05	F .01
Species	.6456	1	.6456	19.2658**	3.94	6.90
Crown Class	.7592	2	.3796	11.3279**	3.09	4.82
Total	177.4345	101				
Error		96	.03351			

Differences between the height growth mean for species and crown classification are highly significant.